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E C O N O M I C S B U L L E T I N

An experimental analysis of two departures from Ricardian equivalence

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Abstract

We construct an overlapping−generations experiment to test for two alleged departures from Ricardian equivalence. In the first treatment the setting is close to the theoretical model, while in the second we allow for liquidity−constrained consumers. We then introduce uncertainty on future income for the first generation. Ricardian equivalence is well supported in the baseline experiment and to some extent in the liquidity−constraint case, whereas it is clearly rejected under uncertainty.

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1. Introduction

Experimental economics has gained a considerable attention and has been effective in shedding some light on several microeconomic fields (e.g., decision theory under risk and uncertainty, public goods, industrial organization). Much less interest has been obtained by macroeconomics. Large-scale macroeconomic experiments are unfeasible because of political and financial considerations. However, modern macroeconomic theory is strongly based on microeconomic assumptions. Therefore, controlled laboratory experiments can be used to test both the aggregate and individual predictions of micro-founded models. Ricardian equivalence is not an exception. It is based on a rational representative agent who maximizes an intertemporal utility function in which the utility of their descendants is an argument, subject to a resource constraint.

Empirical research on this topic is usually carried out by estimating some aggregate consumption functions. While a considerable body of econometric evidence fails to support debt neutrality, many authors maintain that the data demonstrates that Ricardian equivalence holds in a mild version, their argument being that the econometric specification of the tests is incorrect and biased against Ricardian equivalence. The two most important surveys of this topic (Bernheim, 1987; Seater, 1993) conclude with conflicting findings, the former being against and the latter in favor. We believe that the use of the experimental method may add some more evidence to this debate. Ricardian equivalence has already been the topic of one experiment (Cadsby and Frank, 1991; CF thereafter).

The paper is organized as follows. Section 2 reviews the role played by liquidity constraints and income uncertainty in causing departures from Ricardian equivalence. In Section 3 the experimental setting is described and analyzed with reference to similar frameworks. Section 4 discusses the results, and conclusions are drawn in the final Section.

2. Theoretical background

Barro (1974) states the irrelevance of the means of financing government expenditure through taxes or debt. Sufficient conditions for this result are (i) lump-sum taxes; (ii) certainty about future levels of income, public expenditure, rates of return, etc.; (iii) perfect capital markets; and (iv) infinite horizons for households. Under these conditions, the present value of taxes is fixed by the given path of government expenditure. This result applies as long as the government cannot pursue Ponzi schemes in which the public debt can grow faster than the economy, indefinitely. In this case, public borrowing can change the timing of taxes but not the present value. Therefore, the issue of an extra dollar of debt to cut current taxes by one dollar implies an increase by one dollar in the present value of future taxes.

With lump-sum taxes, infinite horizons, and perfect capital markets, the representative household cares only about the present value of taxes. The timing of these levies does not matter. Since a deficit-financed tax cut does not alter this present value, the tax cut does not affect consumer demand. It follows that the extra government bonds issued to finance the tax cut are willingly held by households without any changes in market interest rates. That is, the additional dollar of public dissaving is met by an added dollar of private saving, so that national saving does not change. The Ricardian proposition still holds with some modifications of the basic conditions. For example, the irrelevance proposition is valid if households have finite lives, as long as each household is connected to future generations by a network of active intergenerational transfers based on altruism.

All these conditions have been argued against because of their lack of realism. We are now going to concentrate on the theoretical arguments against Ricardian equivalence based on the existence of liquidity-constrained consumers and on uncertainty about future income. They are preliminary to the experimental analysis we have conducted. According to the literature, one of the most acknowledged departures from Ricardian equivalence is the existence of liquidity-constrained consumers (Heller and Starr, 1979; Hubbard and Judd, 1986). Under the assumption that 20 percent of the population is liquidity constrained a $1 deficit-for-taxes swap could increase current consumption by about 25 cents, a far larger result than the one associated with the only wealth effect (5 cents). If there are inefficiencies in the credit market, some consumers are unable to borrow or can borrow at an interest rate higher than the lending one. Consumers will spend some of the money arising from a tax cut because the government gives them terms of exchange between current and future consumption which makes them better off than the market interest rate. If there is a tax cut, these agents can increase their current consumption (constrained by their inability to borrow against the future income) and pay more taxes in the future. The government allows them to do what the credit market does not permit, and in this way they can increase their utility smoothing consumption all over their lifetime.

Uncertainty on future income is another reason for the failure for Ricardian equivalence. According to Feldstein (1988), even in an economy in which altruism is the only bequest motive, taxes are lump-sum and there is no uncertainty on the date of an individual's death, if second-period earnings are uncertain, bequests also are uncertain at the time of first-period consumption. If the individual knew with certainty that he was not going to make a bequest, the extra tax borne by the next generation would be irrelevant to him, and he could divide his tax cut between his own consumption in the first and second period. The individual raises his first-period consumption knowing that with probability $1 - p$ he will not want to make a bequest and will raise his second-period consumption by the remainder. With probability p the individual will have high income in the second period, will therefore choose to make a bequest, and will use some of his additional first-period saving to make a larger bequest than he would otherwise have made. Therefore, consumption rises more in response to an increase in current disposable income than to an equal present value increase in the disposable income of the next generation.[1]

3. Experimental design

We build our experimental design on CF by imposing in the utility function of parents the utility level attained to their descendants. The parents' utility function is:

$$U_P = C^P{}_1 * C^P{}_2 * U_D, \qquad (1)$$

[1] Strawczynki (1995) obtains a generalization of this result in an infinite horizon model. He shows that because of income uncertainty and precautionary savings, Ricardian equivalence may fail. Government transfers in the "second period uncertainty income case" allow for a substantial reduction in precautionary savings and boost consumption, while in the "future generation income uncertainty case" precautionary savings are only partially affected. In addition, it is useful to point out that the extent of the failure does not depend on the degree of income uncertainty. See also Chan (1983) and Barsky et al. (1986) for reasoning on *ex ante* uncertainty and riskiness of future income.

where: $C^P{}_1$ and $C^P{}_2$ are parents' consumption in period 1 and 2, respectively and U_D is the utility obtained by its descendant, which in turns is:

$$U_D = C^D{}_2 * C^D{}_3, \qquad (2)$$

where: $C^D{}_2$ and $C^D{}_3$ are offspring consumption in period 2 and 3. Our goal is to test whether some alleged departures for Ricardian equivalence are able to significantly change the size of the bequests left to following generations. Therefore we have designed three different experiments. The first one resembles quite closely a Ricardian environment. The second and the third ones depart from that ideal setting, allowing for liquidity-constrained agents and for uncertainty on future income.

In the CF experiment subjects are given a certain role for the whole duration of the game. Their procedure may be vulnerable to "backward induction" (van der Heijden *et al.*, 1998), and therefore testing for Ricardian equivalence would become the same as testing for the ability of subjects to perform this game theory solution concept. Any result achieved in this way may be misleading. To overcome this problem we have taken some of the features of the methodology used by Marimon and Sunder (1993). We have recruited seventeen subjects. The computer randomly selected ten of them, five of which played as parents in the first period. The other five enter into the game in period two, while they play alone in period three. Therefore the game has to start again: five of the seven people that have not played in the first stage are selected to play along with and five of the ten that have already played. The roles of these ten people are randomly selected. It may happen that a person would stay outside the game for more than one period, as well as it is possible to participate in the same role for more than one period. Randomness in the participation to the games should ensure that the planning horizon of the players would not extend to the whole set of games.[2]

In the baseline treatment subjects selected to act in period 1 as parents receive a certain disposable income plus an extra income - which represent the tax cut in the Ricardian story. They are informed about their disposable income, an extra amount of money available in period 2 (disposable income in periods 1 is equal to disposable income in period 2, and the same holds for extra amounts), and the income of their descendants. Money is expressed in artificial experimental units. Therefore, they decide how much to spend and to save in the first period and, when resources become available, in the second period. For simplicity there is no interest rate. They are also informed at the beginning that the extra resources they use are subtracted from their descendants, and the amount of money they save in the second period is given to their descendants. Offspring start playing in period 2 when they get informed about their personal available income in periods 2 and 3, and the amount of extra resources their parents have received. At the and of period 2 parents die, and in period 3 only descendants remain in the game. They receive the

[2] The Ricardian equivalence model aussumes an infinite horizon, which in experimental economics is usually obtained randomly choosing the termination of the game. CF do not follow this procedure and fix the number of repetitions. This violates the infinite horizon hypothesis. However, we have used this aspect of their design to avoid a too many changes in the experimental procedure. In case of rejection of the Ricardian hypothesis in a baseline experiment in which two aspects of the design had been changed, we would be unable to discern whether this happened because of the first change or because of the second, or both. This would have reduced comparability with CF results.

disposable income and the bequest, if any, left to them by their parents, and the extra resources parents have received are subtracted. Then descendants die and the game starts again according to the rules described above. All the decisions are subject to a positive binding.[3]

In the liquidity-constraint treatment agents acting as parents are informed in the first period about the personal disposable income available in periods 1 and 2, noticing that the latter is greater than the former, the extra amounts available in both periods are equal, and heirs' income. In the income-uncertainty treatment, in the first period, parents are informed of their current disposable income, of the extra amounts available in periods 1 and 2, which is equal across periods, and their descendants' income. At the beginning of period 2 they are informed about the personal disposable income for that period, which may be higher, lower or equal to the one received in the first period. In contrast, nothing changes for descendants with respect to the baseline treatment. Across treatments we have given parents the same income.

Typically, in OLG models, agents of each generation are given a certain endowment at the beginning of the first period that they have to allocate between the two periods in which they live. Because of the departures from Ricardian equivalence we wish to study, and for comparability between different treatments, we find this way unfeasible. Giving all the income at the beginning would have made it impossible to model imperfections in the second period, liquidity constraints as well as income uncertainty. CF gave extra income only in the second period. However, to give to liquidity-constrained consumers the possibility to smooth consumption via the tax cut, we have to provide them with additional resources also in the first period.

We report the results from a series of experiments that were undertaken at the University of Siena using the experimental software z-Tree (Fischbacher, 1999). Subjects were first- and second-year undergraduate students in economics with no prior knowledge of Ricardian equivalence. Each experiment composed of 40 games in which two generations participate. Every 10 games the relative magnitude of the parameters changed, that is we have modified the income of each generation and the size of the extra money received, constructing different environments. We call these groups sets. In particular, in the first set there are poor parents, poor descendants and low debt; in the second there are rich parents, medium-income descendants and low debt; in the third there are rich parents, rich descendants and medium debt, and finally there are rich parents, rich descendants, and low debt. This has been done to isolate possible wealth-effects. Subjects were informed of the parameters' switching. Before running the experiment, a quiz was administrated to check the comprehension of the instructions. Five periods of training were allowed before each session. Each experiment lasted about two hours. Subjects received a show-up fee of € 5, and the average gain from the experiment was € 19.3.

[Table 1 about here]

[3] Instructions are available upon request.

4. Analysis of the results

The optimal solution of the consumption problem at hand is to equate consumption in the two periods and for parents to bequeath a sum equal to the extra income received. The hypotheses we test are the following:[4]

HYPOTHESIS 1: *In the baseline treatment, consumption in the first and in the second periods are equal, while in the two other treatments equality does not hold.*

HYPOTHESIS 2: *In the baseline treatment, parents bequeath an amount equal to the extra income they received; in the other two treatments the bequest is lower than the tax cut. Alternatively we can say that net bequest is equal to zero in the baseline and negative in the credit-constraint and uncertainty treatments.*

In this Section we provide evidence on both consumption smoothing and the size of bequests in all treatments.

4.1. Consumption smoothing

In the baseline the equality of consumption in the two periods is obtained on average in 26% of the cases, with values ranging from 16% to 32% among sets. First-period consumption is lower than that of the second-period for 54.5% of the sample. There is a clear difference between the first set and all other sets: 32% compared to values ranging between 56% and 66%.

In the liquidity-constraint treatment equality in consumption is recorded in 8.5% of cases. This percentage is fairly constant among the first three sets, climbing to 27% in the last. Due to the increasing profile of parents' interperiodal disposable income, many subjects (79%) show a tendency to consume more in the second period than in the first, and there is no significant variation among the sets. Subjects in the "uncertainty treatment" consume the same amount in all periods in 9.5% of cases, with the exception of set 1 (16%), and the frequency is similar among the other three sets. Similarly to the baseline, 113 subjects (56.5%) chose to consume less in period 1 than in period 2. These subjects are almost equally distributed among sets.

These frequencies are poor by themselves in representing the effective consumers' behavior. A better understanding may be inferred by comparing other aggregate statistics. Subjects in the first treatment exhibit a strong tendency to smooth their consumption. On average, the difference between their own first and second consumption level is -6.2 units, with a standard deviation of 18.7, and a median value of -2. This attitude is also reflected by the relatively close distribution of individual choices: the interval [-6; 7] includes 140 (out of 200) cases of individual consumption differences; 162 in the range [-10; 10].

Average interperiodal consumption difference is -20.4 in the "liquidity-constraint treatment" (std. dev. 27.77); the median value is -12. Only 81 cases are in the range of [-10; 10], which is precisely half the number of that in the baseline. In the "uncertainty treatment" the average difference is -6. This mean value is close to that calculated for the baseline. The same holds for the median (-3). However, the similarities between the two treatments stop here: just in the interval [-20; 18] we can observe 140 observations.

[4] The analytical solution is available upon request.

Summing up, the structure of the utility function in the overall experiment creates an incentive to equate interperiodal consumption. Agents' performance in reaching this objective depends crucially on the complexity of the context. Consumption smoothing is more likely to occur in the baseline than in the other treatments. Upon interpreting these data we argue that, when agents face situations more complex than an ideal setting they fail, on average, to reach a satisfying level of consumption smoothing. The failure has a double face. There is a higher number of failing agents relative to the entire sample, and the magnitude of the dispersion of their choices is greater.

More formal tests confirm these pictures (Table 2). We perform a series of Wilcoxon rank-sum tests (Siegel and Castellan, 1988) under the null hypothesis that on average consumption in the first period is equal to consumption in the second period. The alternative hypothesis is two-tail, since we do not have an explicit expectation on this hypothesis. Results show that we the cannot reject the null hypothesis at the 10% significance level for the baseline, while we can reject the null in the liquidity-constraint treatment at the 1% significance level and at the 5% in the uncertainty treatment.

[Table 2 about here]

4.2. Bequest size and motive

We can now analyze subjects' choices concerning the second relevant decisional variable, the net bequest (the difference between the bequest left to the offspring and the tax cut whose burden falls on the second generation). In the ideal setting, the baseline treatment, by aggregating agents' choices we obtain a mean of 2.6 units (std. dev. 18.6) end a zero median value. A little bit more than half the observations belong to the interval [-5; 11]. The summary statistics on net bequest as a percentage of the total amount of debt issued, shows to be good news for Ricardian equivalence. On average, subjects leave 6.5% more than the sum strictly necessary. More than half of the cases (103), bequeaths an amount between -15 and 15%. Less than 5% of the observations choose values that pay just half of the tax burden or less.

When facing liquidity-constraints, aggregate behavior does not support the conclusion in favor of a Ricardian bequest motive with the same strength as before. Even exhibiting a zero median value and a mean of -2.1 units, observations are more widely distributed. The amplitude of the range, which includes half of the observations, is much bigger than in the previous case [-19; 11]. Note this expansion is totally charged to the negative direction of the horizontal axis, the upper limit of the interval being unchanged, reflecting the augmented weight of negative net bequest choices. In addition, 20% of subjects leave resources covering half of the tax burden or less. Results from the "uncertainty treatment" are even worse: the median value for net bequest is -13 units and -29% of the debt to be repaid. In representing these observations mean values (-6 as in absolute terms as in percentage) can generate some illusive effect. They are distorted by 9 (5% of the total) observations, whose bequest is 3 times the necessary sum or even more. Recalculating mean values after having excluded these outliers gives a mean of -11.4 units or -20%.

We have calculated again the Wilcoxon rank-sum test under the null hypothesis that the mean of debt is equal to the mean of bequest left to the subsequent generation. Table 3 shows that we cannot reject the null for the baseline, whereas non-rejection is borderline in the liquidity-constraint treatment. Under uncertainty we can clearly reject the null.

[Table 3 about here]

Dealing with an uncertain income profile, agents usually fail to make precautionary savings. In the second period subjects face a dilemma if parameters prescribe a diminishing income profile. They can either use the amount of debt to smooth consumption or save it for the benefit of their future generation. Usually they choose an intermediate solution: part of the debt is consumed, the rest is bequeathed. As it has been graphically shown, their decisions do not allow us to conclude that they are effective in smoothing their consumption.

5. Conclusions

We have presented the results of a series of experiments in which we have tested for possible departures from Ricardian equivalence. In doing so we have improved upon previous studies dealing with the same topic, in two directions. Firstly, we have considered two well-known theoretical causes of the likely failure of Ricardian equivalence. Secondly, we have used a matching rule that has been extensively used in monetary economics experiments that rules out the possibility of supergame effects. We are able to accept the idea that debt neutrality works with some approximations in the baseline, while uncertainty on future income makes very likely debt neutrality failure. Under liquidity constraint agents do not equate consumption over the two periods and, as a result, they appear (to some extent) to leave their offspring with enough wealth. Finally, a word of caution is needed, since these results are based on few observations. We plan to overcome this limitation, together with the infinite horizon issue, running further experiments.

Table 1 – Experimental parameters

Treatments	Parents			Descendants	
	1st period income	2nd period income	Total tax-cut	1st period income	2nd period income
Baseline 1st set	16	16	23	25	25
Baseline 2nd set	69	69	19	24	24
Baseline 3rd set	56	56	40	70	70
Baseline 4th set	21	21	18	47	47
Liquidity constraint 1st set	10	22	23	25	25
Liquidity constraint 2nd set	45	93	19	24	24
Liquidity constraint 3rd set	35	77	40	70	70
Liquidity constraint 4th set	17	25	18	47	47
Uncertainty 1st set	17	15	23	25	25
Uncertainty 2nd set	69	69	19	24	24
Uncertainty 3rd set	58	54	40	70	70
Uncertainty 4th set	20	22	18	47	47

Table 2 – Wilcoxon rank-sum test for parents' consumption

Treatments	Test statistic	p-value
Baseline	-1.820	0.069
Liquidity-constraint	-6.392	0.000
Uncertainty	-2.033	0.042

Table 3 – Wilcoxon rank-sum test for debt and bequest

Treatment	Test statistic	p-value
Baseline	-1.254	0.210
Liquidity-constraint	1.687	0.094
Uncertainty	4.518	0.000

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